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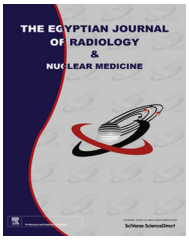

ORIGINAL ARTICLE

Evaluation of the efficacy of Virtual Colonoscopy in assessment of colorectal lesions using conventional Optical Colonoscopy as the gold standard

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Colon cancer;
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Abstract Colorectal pathology in the present era is a major cause of morbidity and mortality. Optical Colonoscopy has been the Gold Standard investigation for the diagnosis of colorectal diseases however a better investigation is required to attain high diagnostic yield along with minimal invasiveness and good patient acceptance. Virtual Colonoscopy offers another modality for assessment of colorectal pathology and promises to play an important role in the future in this regard.
Method: Forty-two patients suspected of having colorectal lesions were included in the present study over one year period. Patients were assessed by Optical Colonsocopy (OC) and Virtual Colonoscopy (VC) and the efficacy of VC was compared statistically with OC.
Results: 38 patients demonstrated lesions in a study population of 42 on OC. VC was able to detect lesions in 37 patients. The sensitivity and specificity of VC was 97.4% and 100% respectively. The results obtained by VC were comparable to OC ($p > 0.05$).
Conclusion: Virtual Colonoscopy is a new 3D diagnostic modality. Its efficacy in lesion detection, less time requirement for performance, good patient compliance, and detection of extracolonic

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lesions in addition to colonic findings make it a favourable choice for assessing colonic lesions.

1. Introduction

Colorectal pathology has always been a major source of morbidity and mortality. Benign as well as malignant pathologies affecting the large gut put a great constraint on the limited health and financial resources. The most well known and probably one of the best studied pathologies amongst these is the Colorectal cancer. Colorectal cancer (CRC) is a leading cause of mortality due to cancer in the Western world. More than 1,000,000 new cases occur per year. There is an estimated lifetime risk of 5–6% in the west due to Colorectal cancer (CRC) with nearly 50% mortality (1). Colorectal cancer (CRC) is the third most common cancer in men (10.0% of the total cancers) and the second in women (9.4% of the total cases) worldwide (2). Out of all the countries the highest incidence occurs in Australia, New Zealand and Western Europe, while the lowest reported incidences are in Africa (except Southern Africa), Central and South Asia (2).

The 5-year survival rate for patients with colorectal cancer is presently reported to be 83–90% if disease is confined to the bowel wall and less than 10% if there are distant metastases; thus, early detection and treatment are critical (3).

Numerous methods such as Faecal occult blood testing (FOBT), double contrast barium enema (DCBE), flexible sigmoidoscopy (FS) and Optical Colonoscopy (OC) have been used with varying efficacy for the screening and evaluation of colorectal lesions so as to facilitate treatment at the earliest. Apart from Optical Colonoscopy (OC) other investigations have relatively low sensitivity and specificity in detecting colorectal pathology. (See Figs. 1–4).

Virtual Colonoscopy (VC) is a technique for the detection of colorectal mass lesions. Virtual Colonoscopy uses advanced visualization technology that permits a minimally invasive, structural evaluation and rapid imaging of the entire colorectum (4,5).

The technique permits evaluation of the colon proximal to obstructive lesions, and also of extracolonic abdominal and pelvic organs. Virtual Colonoscopy (VC) is less invasive than conventional Optical Colonoscopy (OC) and does not require sedation. There is a low risk of procedure related complications associated with Virtual Colonoscopy (VC). Preliminary studies show that patients prefer Virtual Colonoscopy (VC) to both double-contrast barium enema and Optical Colonoscopy (OC). We prospectively compared multidetector Virtual Colonoscopy (VC) with Optical Colonoscopy (OC) for the detection of colorectal polyps and cancer.

2. Materials and methods

The present study was conducted in the Department of Radio-Diagnosis and Department of Gastroenterology, I.G.M.C., Shimla over a period of one year w.e.f. 1st June 2011 to 31st May 2012. Forty-two patients having signs and symptoms of colorectal lesions (abdominal pain, diarrhoea, constipation, lower gastrointestinal bleeding, anaemia, weight loss) as well as those suspected of lesions on other screening tests were included in the present study. Patients with contraindications to contrast enhanced CT scan, intestinal obstruction, gut perforation or other contraindications were excluded from the present study. In them, Virtual and Optical Colonoscopy were performed within two weeks of each other. Virtual Colonoscopy data were reported using CT Colonography Reporting and Data System (C-RADS).

All patients gave informed consent, and the study was approved by the institutional Ethics Committee.

2.1. Virtual Colonscopy (VC) preparation

The patients included in this study received a low residual diet for 2 days before the examination with Virtual Colonoscopy. The bowel was prepared with 2 l of polyethylene glycol electrolyte solution (Peglec Tablet, India limited) received 6 h prior to the procedure. The Virtual Colonoscopy was performed on 64 slice MDCT GE (General Electronics) LIGHT SPEED VCT Xte machine, with 5 mm collimation, 40 mm detector coverage, 0.6 s rotation time, tube current between 80 and 250 mAs and tube voltage between 100 and 120 kvp.

The patient was placed in the left lateral decubitus position and the colon was insufflated with 40 puffs (approximately 50 ml/puff) of room air or up to the tolerance of patient, gently through a rectal tube or Foley's catheter whichever was available. Scan was performed from the dome of diaphragm to the lower end of the ischial tuberosity. A CT scout image was obtained to ensure adequate bowel distension in the prone position. Unenhanced scan was taken in the prone position. However, before scanning patient in the supine position, the colonic distension was ensured by insufflating additional air to patient's maximum tolerance and checked by taking a second CT scout image. Adequate colonic distension was ensured by a repeat scout film and additional air insufflations were provided if required. An iodinated non-ionic contrast (80 mL) was injected intravenously at 4 mL/s using a pressure injector, and images were acquired in the portal venous phase in supine position. All scans were obtained in cranio-caudal direction with suspended respiration.

3. Data analysis

3.1. Image processing

The reconstructed image data from both supine and prone scans was networked to the real time interactive workstation Advantage Windows version 4.5 (GE Medical systems). Axial 2D CT images and endoluminal 3D reconstructions were obtained. The datasets were examined as continuous 0.625 mm thick sections in the axial view as primary display method. Any abnormality detected during the review of axial sections was further subjected to coronal and sagittal multiplanar reformatted images as well as volume rendered endoluminal views using a fly through the mode of navigation system for verification.

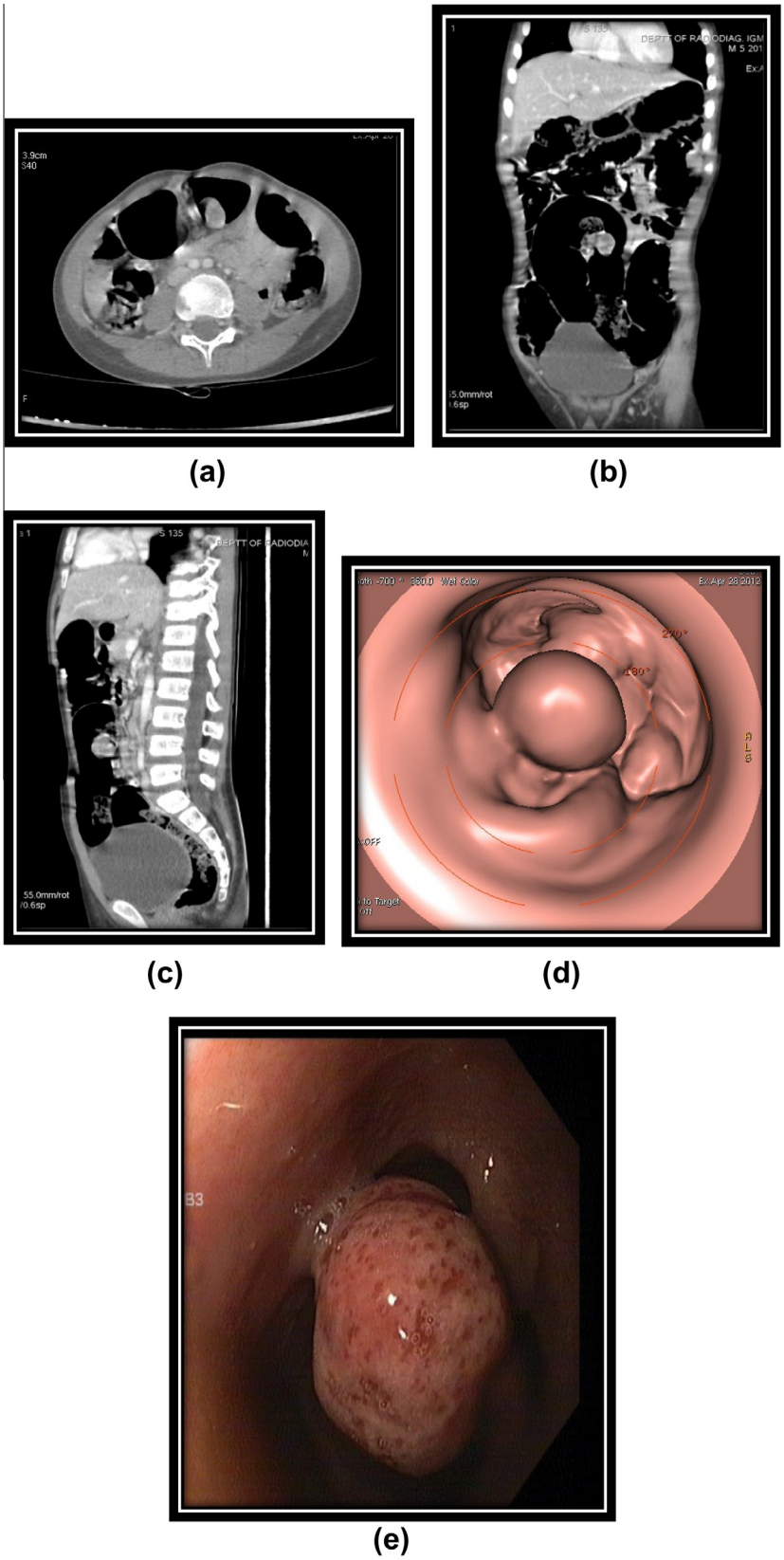

Fig. 1 Pedunculated polyp in a 5-year-old male child histologically proven as benign adenomatous polyp. (a), (b) and (c): Axial (supine), coronal and sagittal Contrast Enhanced CT shows a single pedunculated polyp in the sigmoid colon respectively. (d) and (e): Three-Dimensional Endoluminal view of Virtual colonoscopy and Optical colonoscopy respectively shows the same polyp.

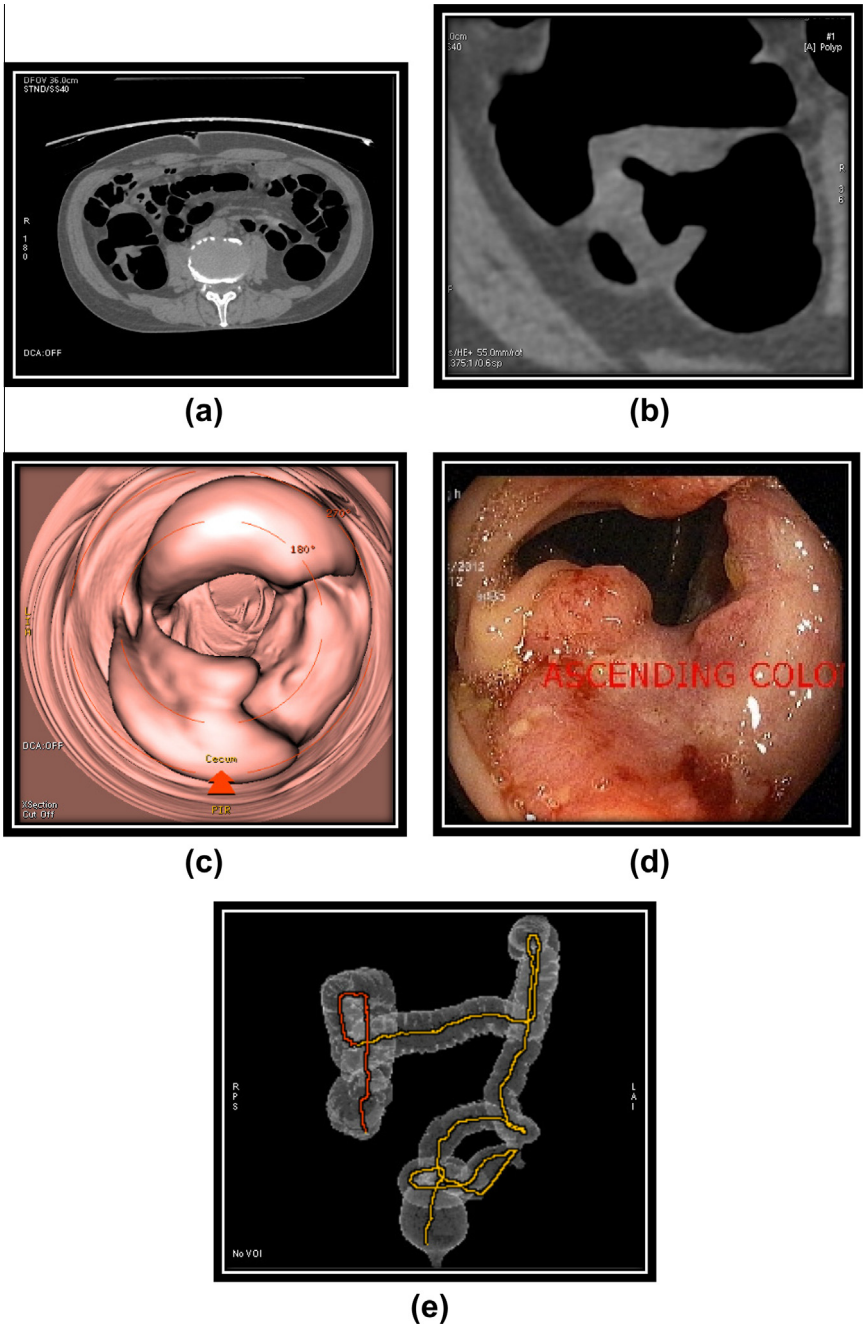

Fig. 2 Well differentiated adenocarcinoma in a 65-year-old male. (a) Axial (prone) CT colonoscopy image showing irregular thickening of the haustra in the ascending colon. (b) Transverse 2D MPR shows better appreciation of the growth. (c) Endoluminal view of Virtual Colonoscopy showing growth involving the ascending colon. (d) Confirmation of growth involving the ascending colon in the optical colonoscopy (e) Volume rendered image depicts lesion in the ascending colon.

3.2. Image analysis

The data obtained were analysed independently by at least two experts from the Department of Radio-Diagnosis IGMC who were unaware of clinical data of the patient as well as results of previous imaging or screening modality. The differences of opinion in any case were resolved by consensus.

For the study purpose the colon was divided into six segments i.e. the caecum, the ascending colon, the transverse colon, the descending colon, the sigmoid colon and the rectum. Lesions detected were described in terms of their size, number, morphology, location and extent.

4. Optical Colonoscopy

Optical Colonoscopy was performed by an experienced gastroenterologist in the Department of Gastroenterology using standard colonoscopy instruments (EVIS EXERA II colonovideoscope standard set model CF-H 180 AL). The observations were made regarding the site, number, morphology,

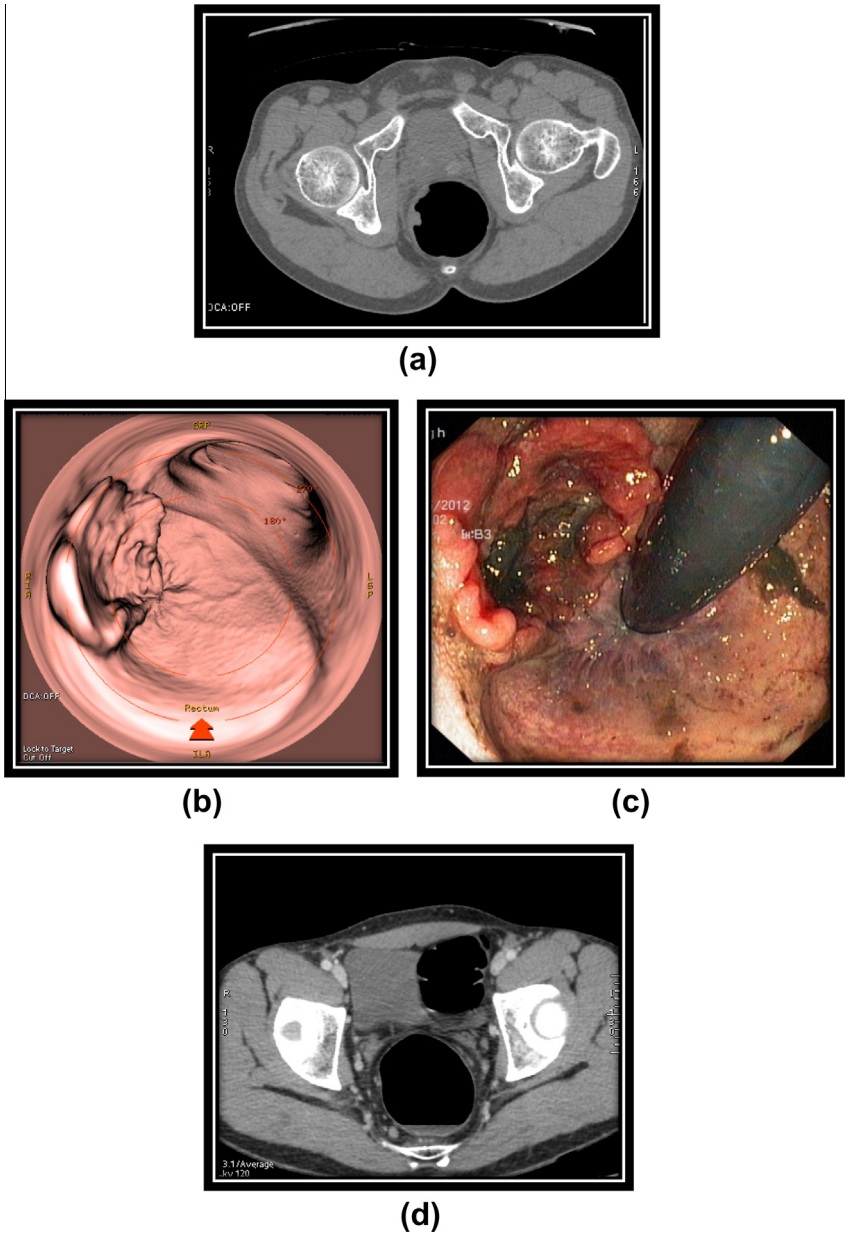

Fig. 3 Ulceroproliferative growth involving the right lateral wall of the rectum in a 37-year-old male. (a) Axial (prone) image of CTC showing ulceroproliferative growth in the rectum (b) and (c) depicts the growth on the right lateral wall in the Virtual and Optical Colonoscopy respectively. (d) Axial (supine) CE CT image demonstrates lymphnode in the pararectal region.

and extent of the colorectal lesions. Biopsy was performed when the lesion was detected. Irrespective of the fact whether Virtual Colonoscopy or Optical Colonoscopy was done earlier, the performer was blinded to the findings of the first study performed at the time of evaluation by the second technique. The results obtained by both the methods were compared thereafter with the results of Optical Colonoscopy being considered as the Gold Standard. The efficacy of Virtual Colonoscopy as a tool to assess colorectal lesion was calculated statistically.

4.1. Statistical analysis

Results of Virtual Colonoscopy were compared with the results of Optical Colonoscopy taking the latter as the Gold Standard in terms of sensitivity, specificity, positive predictive value and negative predictive value with $>95\%$ of confidence limit. Descriptive analysis and kappa analysis were applied as per requirement.

5. Results

Forty-two (42) patients were evaluated by Virtual Colonoscopy and Optical Colonoscopy in the present study. Four (4) patients had no lesion evident on both the techniques and were considered negative cases. The two modalities were considered for a comparison of findings in 38 positive cases only.

Out of the total 38 positive cases, 22 (57.9%) patients were males and 16 (42.1%) were females. The mean age of presen-

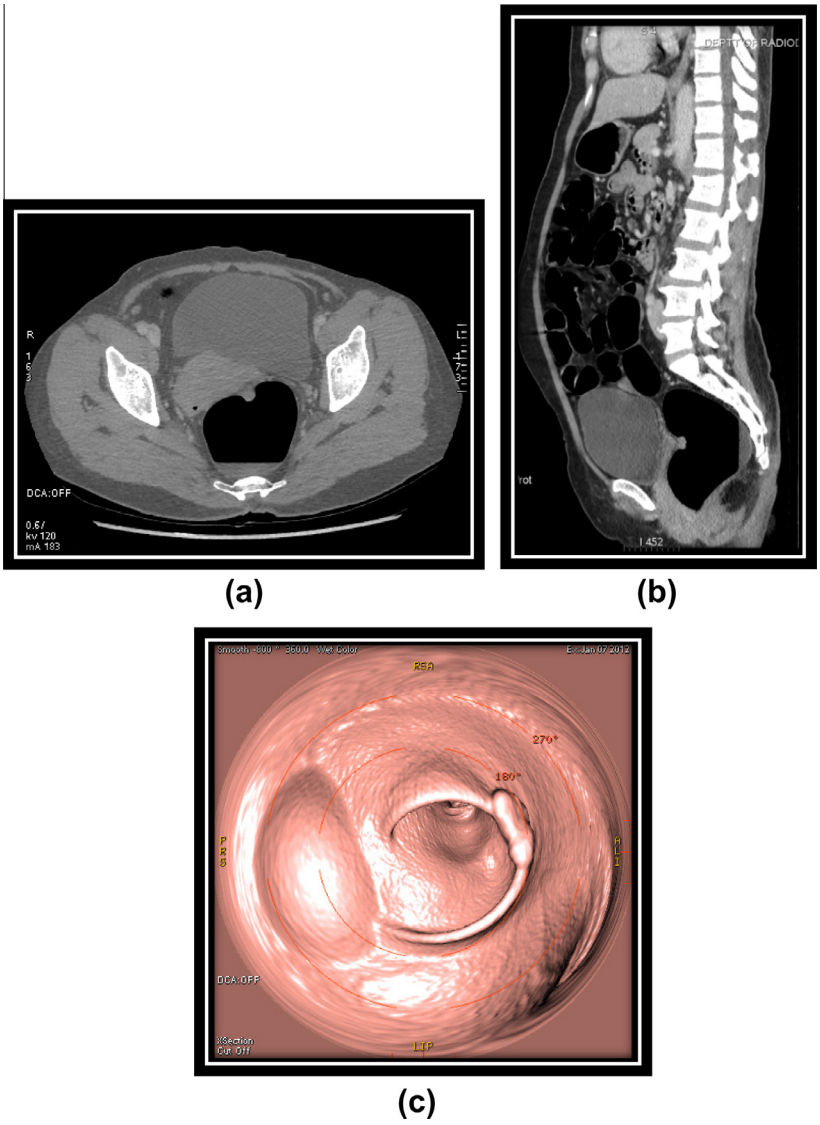

Fig. 4 Sessile polyp proven as adenocarcinoma present in the anterior wall of rectum of a 44-year-old female (a) and (b) Axial and sagittal supine CTC image showing a sessile polyp less than 10 mm in maximum dimension projecting into the lumen (c) Three–Dimensional Endoluminal view of Virtual Colonoscopy demonstrates the same lesion as focal thickening of haustra.

tation was 53.68 ± 16.82 years. Most patients (78.94%) belonged to the age group between 41 and 80 years of age.

Main complaints of patients were bleeding per rectum (63.3%), altered bowel habits (10.5%), anaemia (10.5%), and pain abdomen (7.9%). Nineteen patients (50%) were smokers, out of which 13 (34.22%) were males and 6 (15.78%) were females. Anaemia was prevalent in 27 (71.1%) cases. Nine patients (23.7%) had ulceroproliferative growth on per rectum examination. Three (7.9%) had annular stenosing growth while polypoidal mass was palpable on per rectum examination in one patient (2.6%). Twenty-five patients (65.8%) with colorectal lesion had no abnormality detectable on per rectum examination.

On Virtual Colonoscopy (VC), lesions were detected in 37 patients while on Optical Colonoscopy (OC) lesions were detected in all of the 38 patients. There were 2 synchronous lesions in a single patient detected by both Optical and Virtual Colonoscopy. In 38 patients there were a total of 39 lesions. Out of these 39 lesions (37 single and 2 synchronous), Virtual Colonoscopy therefore detected 38 and Optical Colonoscopy detected 39 lesions. The sensitivity of Virtual Colonoscopy to detect lesion was 97.4% and specificity was 100%. Optical Colonoscopy being the Gold Standard had a sensitivity and specificity of 100%. The positive predictive value was 100% and negative predictive value was 80% for Virtual Colonoscopy.

There was a high level of agreement between Virtual and Optical Colonoscopy on colonic findings of Kappa analysis (value 0.898 and $p < 0.05$).

The distance of the lesion from the rectum was measured by both Virtual and Optical Colonoscopy. It was however not feasible to measure the distances of all the lesions with Optical Colonoscopy as curvatures and folds in the large gut made measurements difficult. The distance of the lesion from the rectum was measured in 37 patients (97.36%) using Virtual Colonoscopy; whereas Optical Colonoscopy measured the distance in 11 patients (28.95%).

Rectosigmoid region was involved in a majority of the patients (66.4%). The right side of the colon was involved in 10 patients (26.3%) and the transverse colon was involved in one patient (2.6%) on Virtual Colonoscopy. One lesion (2.6%) which was missed on Virtual Colonoscopy involved the right side of the colon.

The increased occurrence of colorectal pathology in the rectosigmoid region was found to be statistically significant with p value < 0.05 on applying non parametric Chi Square test.

The size of the lesion was measured in Virtual Colonoscopy. Difficulty was encountered in measuring the size of the lesion with Optical Colonoscopy, owing to curvatures of the large gut and the absence of an accurate measuring instrument. On Virtual Colonoscopy, one lesion with a size < 1 cm was detected, three lesions measured between 1 and 2 cm. The remaining 34 lesions were > 2 cm in size on Virtual Colonoscopy. The smallest lesion described was 0.9×0.8 cm and the largest lesion was $11.2\text{ cm} \times 2.9\text{ cm}$ in size. Morphologically, lesions were described as ulceroproliferative/ulcerative, stenosing and polypoidal. Lesions were ulceroproliferative in 24 patients (61.4%) on both Virtual Colonoscopy and Optical Colonoscopy. In 12 patients (30.8%) lesions were found to be annular stenosing. In two patients lesions (5.2%) appeared polypoidal on both Virtual Colonoscopy and Optical Colonoscopy. The lesion which was not detected by Virtual Colonoscopy appeared ulcerative on Optical Colonoscopy.

Extracolonic findings were evident in 35 patients (92.1%) on Virtual Colonoscopy. The most common extracolonic finding was regional lymphadenopathy which was evident in 19 (50%) patients. Other findings included visceral or peritoneal involvement by tumour; renal calculus disease, ovarian cyst and cholelithiasis.

Lesions were classified according to the CT Colonography Reporting and Data System (C-RADS). Thirty-six patients (94.8%) had a C4 lesion while a single patient (2.6%) had a C3 lesion. One patient's lesion was not picked up by VC.

Extracolonic findings were suggestive of E1 lesion in 3 patients (7.9%). A single patient (2.6%) had E2 lesion and 6 (15.4%) had E3 lesion. Twenty-seven patients (71.01%) had E4 lesion.

The lesions detected on OC were biopsied and sent for histopathological examination (HPE). Benign adenomatous polyp was reported on histopathological examination in a single case; remaining lesions' histopathology reports were suggestive of adenocarcinoma.

The mean duration of procedure in Virtual Colonoscopy was 12.57 ± 1.56 min and 23.83 ± 2.98 min. in Optical Colonoscopy.

The difference in the duration of the two procedures was statistically significant on paired T test with a p value < 0.05.

Out of the 42 patients, 37 (88.1%) patients said that they would prefer Virtual Colonoscopy over Optical Colonoscopy for the evaluation of the colon while 5 patients' (11.9%) preference was Optical Colonoscopy over Virtual Colonoscopy. On applying the Chi Square test, a significant difference was found ($p < 0.05$) in patient's preference for Virtual Colonoscopy over Optical Colonoscopy. Patients preferred Virtual Colonoscopy because of less discomfort and shorter duration of the procedure.

None of the patients had any complication during or after the procedure in any of the two used modalities.

The mean effective dose of radiation in Virtual Colonoscopy was 7.45 ± 0.61 mSv, the minimum and maximum being 6.3 mSv and 8.8 mSv respectively.

Virtual Colonoscopy was completed in all 42 cases. While performing Optical Colonoscopy the colon could not be evaluated completely in seven cases owing to proximal obstructing lesions which prevented an assessment of the bowel proximal to the affected site. On performing the Chi Square test for categorical data, this inability of Optical Colonoscopy to complete the procedure was found to be statistically significant with a p value < 0.05.

6. Discussion

Optical colonoscopy is considered to be the Gold Standard investigation for the detection of colorectal pathology. Its excellent ability to pick up the lesions along with the advantage of providing tissue biopsy makes it a forerunner in the available diagnostic modalities. It however is not infallible and is limited in situations such as obstructive pathology and in an uncooperative patient. Being an invasive procedure, it requires sedation and is time consuming, making it relatively less tolerable by an average patient (6). Despite its efficacy, small polyps less than 1 cm may be missed in 10–20%; the entire colon may not be visualized in 5–10% of cases which along with the risk of bleeding and perforation of the gut (0.1–0.3%) highlights the need for better diagnostic modalities for colonic assessment (6).

Virtual Colonoscopy (VC) is a technique for the detection of colorectal mass lesions. This procedure has already proved its significance amongst a variety of other available diagnostic options. Virtual Colonoscopy uses advanced visualization technology that permits a minimally invasive, structural evaluation of the entire colorectum. It has several potential advantages over other screening tests, including rapid imaging of the entire colorectum; a relatively noninvasive technique, with no need for sedation; and a low risk of procedure related complications. Virtual Colonoscopy is currently performed in symptomatic patients of suspected colorectal pathology as well as in patients with failed or incomplete Optical Colonoscopy which in turn may be due to reasons such as colorectal cancer, diverticular disease, redundant colon, adhesions, residual colonic content, patient intolerant to Optical Colonoscopy or other factors. It is also used along with Optical Colonoscopy in order to establish the diagnosis as well as for staging the pathology. In addition it can also evaluate the abdomen for local tumour spread, visceral or lymph node metastasis and for staging. Complication rate with Virtual Colonoscopy has been reported to be less compared with Optical Colonoscopy, with a reported perforation rate between 0.03% and 0.009% respectively (7).

Virtual Colonoscopy is also preferred in patients where Optical Colonoscopy is contraindicated as in patients with severe cardio-pulmonary disease, coagulation abnormalities or on anticoagulant therapy and frail patients who might not tolerate the procedure.

In a systematic review and metaanalysis involving forty-nine studies that provided data on 11,151 patients with a cumulative colorectal cancer prevalence of 3.6% (414 cancers) the sensitivity of Virtual Colonoscopy for colorectal cancer was 96.1% (398 of 414; 95% confidence interval [CI]: 93.8%,

97.7%). The sensitivity of Optical Colonoscopy for colorectal cancer, derived from a subset of 25 studies including 9223 patients, was 94.7% (178 of 188; 95% CI: 90.4%, 97.2%) (8). The results of this study concluded that VC is highly sensitive for colorectal cancer, especially when both cathartic and tagging agents are combined in the bowel preparation.

The sensitivity of Virtual Colonoscopy in this meta analysis correlated well with the result of the present study where a sensitivity of 97.4% was obtained. The ability of Virtual Colonoscopy to detect lesion increased with the increasing size of the lesion. For lesions less than 5 mm in size the reported sensitivities of Virtual Colonoscopy dropped sharply to around 50%. Diminutive colonic lesions (< 5 mm in size) are considered as clinically insignificant. Only few of these lesions are adenomatous on histology, with fewer than 1% being histologically advanced, and almost none being malignant. Thus despite its unimpressive yield at lower lesion sizes, Virtual Colonoscopy in the light of the above mentioned data appears to be a good mode of investigation for screening and assessment of colorectal lesions.

One lesion was missed by Virtual Colonoscopy in the present study. The lesion was located in the right side of the colon with ulcerative morphology although its size was not mentioned on Optical Colonoscopy.

Extracolonic involvement was present in 35 (92.1%) out of 38 patients. Commonest findings were regional lymphadenopathy (50%), visceral and peritoneal involvement.

A limitation of the present study was its smaller sample size. A larger prospective study is required to effectively establish the results that were achieved in the present study. The study did not include the surgical findings of the same patients which could have aided in correlating the findings observed on both Optical Colonoscopy and Virtual Colonoscopy.

In conclusion Virtual Colonoscopy appears to be an effective, reliable and fast method to assess colorectal pathology and along with Optical Colonoscopy seems to be the main diagnostic tool for evaluating the colon and rectum. Virtual Colonoscopy and Optical Colonoscopy should be considered as prime modalities for disease assessment rather than considering them as competing diagnostic tools. Together these two investigations form the backbone of the imaging of colorectal pathology greatly facilitating the appropriate treatment of the disease.

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